



NEOGENE VERTEBRATE PALAEOICHOLOGY OF THE NORTH ATLANTIC COAST OF THE RIO NEGRO PROVINCE, ARGENTINA ¹

(With 10 figures)

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ABSTRACT: Tetrapod footprints assigned to mammals and birds were discovered at continental deposits from the Atlantic coast of Rio Negro Province, Argentina. The study took place along 30km of a marine beach area between Balneario El Condor and La Lobería (41°S, 62°30'-64°30'W); in the region, abrasion platforms crop out as remnants of eroded high cliffs. The stratigraphic sequence begins with continental deposits at the base of the profile, followed by marine sediments and continental beds cropping out on the cliff wall; thus the stratigraphic range of the continental ichnofauna extends from late Miocene (imprints on abrasion platforms) to early Pliocene (footprints on fallen rocks, lying at the base of the cliffs). The footprints are assigned to tardigrad xenarthrans (*Megatherichnum oporto*i and cf. *Myodontidichnum* isp.); ungulates *indet.* A trackway assigned to a carnivorous marsupial and isolated footprints of a hydrochoerid rodent also occur, as well as trace fossils assigned to phorusrhacids birds and flamingos, among others. The ichnofauna is registered in interdune pool and ephemeral lagoon sediments, such as it is indicated by lacustrine deposits with desiccation mud-cracks.

Key words: Palaeoichnology. Mammals. Birds. Late Miocene. Early Pliocene.

RESUMO: Paleoicnologia de vertebrados do Neógeno da costa do Atlântico Norte da Província do Rio Negro, Argentina.

Pegadas de tetrápodes atribuídas a mamíferos e aves foram descobertas em depósitos continentais da costa atlântica da Província de Rio Negro, Argentina. O estudo foi realizado ao longo de 30km da praia entre os Balneários El Condor e La Lobería (41°S, 62°30'-64°30'W); na região, plataformas de abrasão afloram como remanescentes de grandes falésias erodidas. A seqüência estratigráfica se inicia com os depósitos continentais na base do perfil, seguido por camadas de sedimentos marinhos e continentais. A variação estratigráfica da icnofauna continental se estende do Mioceno Superior (impressões em plataformas de abrasão) ao Plioceno Inferior (pegadas em seixos rolados, situados na base da falésia). As pegadas são atribuídas a xenarthras tardígrados (*Megatherichnum oporto*i e cf. *Myodontidichnum* isp.); ungulates *indet.* São também observados uma pista, atribuída a um marsupial carnívoro, e pegadas isoladas de um roedor hidroquerídeo, assim como traços fósseis atribuídos a aves da família Phorusrhacidae e a flamingos, entre outras. A icnofauna é registrada em sedimentos de reservatório interdunar e de lagoas efêmeras e temporárias, assim como é indicado por depósitos lacustres com gretas de contração.

Palavras-chave: Paleoicnologia. Mamíferos. Aves. Mioceno Superior. Plioceno Inferior.

INTRODUCTION

Tetrapod footprints assigned to mammals and birds were discovered at continental deposits from the Atlantic coast of Rio Negro Province, Argentina, in addition to earlier findings (CASAMIQUELA, 1974; ANGULO & CASAMIQUELA, 1982; ARAMAYO, 1999; ARAMAYO *et al.*, 2004). Footprints are impressed on abrasion platforms cropping out along 30km marine beach between Balneario El Cónдор and La Lobería (41°S, 62°30'- 64°30'W) (Fig.1).

GEOLOGICAL SETTING

The abrasion platforms are remnants of eroded high cliffs, with an average height of 50m, extending from East to West; footprints are impressed either on silty clay platforms or on the plane surfaces of fallen blocks lying at the base of the cliffs. The stratigraphic succession begins with continental aeolian deposits at the base of the section, followed by a marine level providing a rich invertebrate fauna. At the top of the sequence, lacustrine deposits crop out bearing

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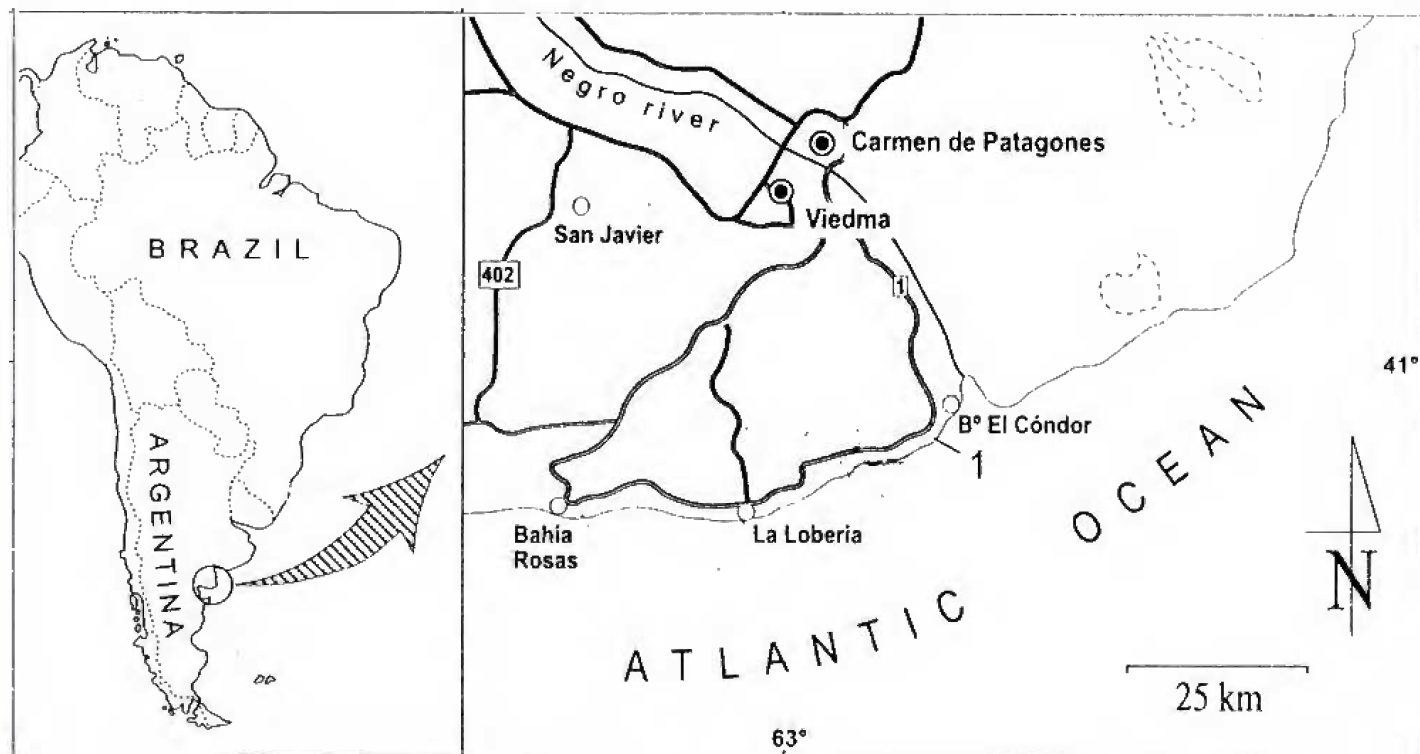


Fig.1- Location map. 1: Lighthouse beach.

trace fossils preserved such as those from the basal deposits. The whole sequence is referred to Río Negro Formation, from Late Miocene to Early Pliocene age; each unit are lower, middle and upper Members (ZAVALA & FRELJE, 2001) (Fig.2).

Trace fossils are impressed on platforms and on the plane surfaces of the fallen blocks. Trackways found at La Lobería belong to the Lower Member and some details are not clearly preserved. In contrast, those occurring in slabs of The Upper Member cropping out towards the East of the cliff exposures, near the Lighthouse access to the beach, show a high quality of preservation.

Abbreviations: Institutional. P.ICHN.U.N.S., Paleoichnology repository, Universidad Nacional del Sur.

ICHNOTAXONOMY

Ichnogenus: *Megatherichnum* Casamiquela, 1974

Ichnospecies: *Megatherichnum oportoi*
Casamiquela, 1974

Occurrence – 7km to the west of Lighthouse beach,

Atlantic coast, Río Negro Province, Argentina.

Description – A trackway of eight footprints impressed by the hind feet of ground sloths (*Xenarthra*, *Tardigrada*) in a plantigrade stance and preserved as a concave epirelief. Each footprint has an elliptical shape, rather wider in the anterior part, and disposed in a parallel way as regards the middle line of the trackway. A rim is observed on the anterior and lateral side due to the rotated position of the feet stepping on the lateral side of the foot. Also a deep subtriangular scar is observed at the inner anterior rim assigned to the scar of the 3rd toe claw. A bipedal locomotion is inferred from the trackways (Figs.3A-B).

Dimensions – Trackway: length: 4.50m; width: 0.80m; step angle: 97°; stride: 0.70m. Footprint (average): length: 0.50m; width: 0.30m; depth: 0.10m

Discussion – The ichnotaxonomic assignation is adopted from CASAMIQUELA (1974), who described some footprints observed on fallen blocks; however, sizes are rather smaller assuming that there is a kind of variation in size among specimens of the same species.

CASAMIQUELA (1974) and ANGULO & CASAMIQUELA (1982)

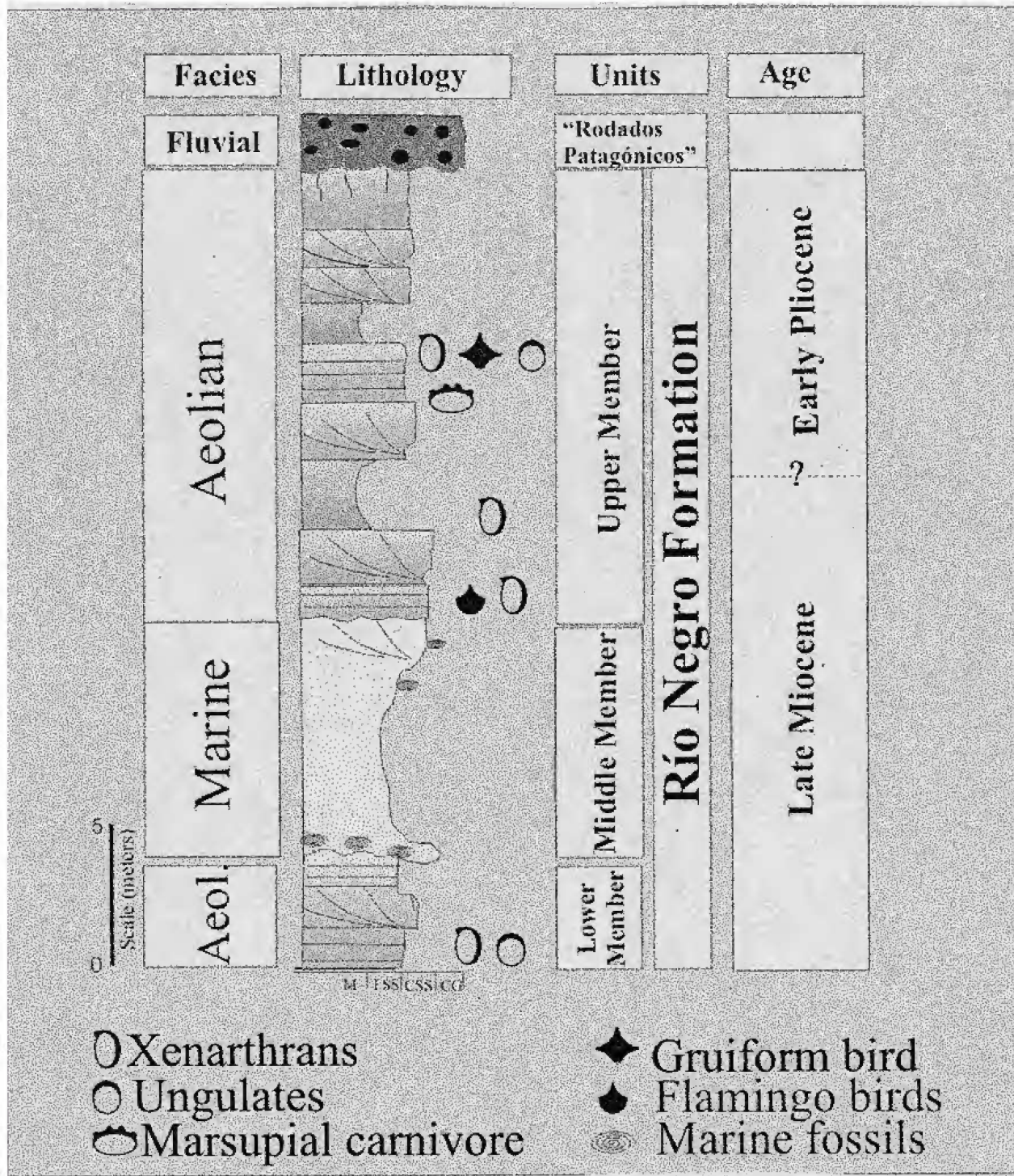


Fig.2- Stratigraphic sequence (modified from ZAVALA & FREJE, 2001).

described the posterior part (or heel) of the footprint as bearing a scar, when the scar was indeed printed by the third finger toe. The latter is confirmed by the great number of ground sloth trackways registered at Pehuen-Co palaeoichnological site (ARAMAYO & MANERA DE BIANCO, 1987, 1996).

The measured step angle is of very low value considering a bipedal locomotion. The latter one is due to the unusual anatomy of ground sloth tarsus, unable to flex the foot up and down (ARAMAYO, 2001); the astragalus tibial trochlear joint is formed by a flat external facet and a prominent upwards

projection on the inner side (odontoid process), thus only inward rotation movements are produced. The displacement rim on the lateral side supports that ankle morphology.

cf. *Myodontidichnum* isp.

Occurrence – A trackway registered on a fallen block found at 1.5km to the west of Lighthouse beach.

Description – The footprints are impressed on a red clay platform at the base of the cliff; they are assigned to a plantigrad mammal of median to small size, forming a trackway of ten footprints in concave epirelief. The footprints are subelliptical, with same width in the anterior and medial part, narrower in the posterior part. The scar of the third toe claw is observed (Fig.3C).

Dimensions – Trackway: total length: 3m; width: 0.80m; stride: 0.60m; step angle: 75°. Footprint (average): length: 0.30m; width: 0.15m; depth: 0.11m.

Plaster cast – P.ICHN.U.N.S. 100

Discussion – This trackway is assigned to cf. *Myodontidichnum* isp. Aramayo & Manera de Bianco, 1987, ichnotaxon from the Late Pleistocene site at Pehuen-Co with similar features but bigger in size. This is consistent with the existence of ground sloths of smaller size like *Proscelidodon* sp. registered at Late Miocene/Early Pliocene mammal ages.

Ungulates indet.

Occurrence 1 – Lighthouse beach.

Description – A trackway of 19 footprints preserved as negative epirelief (subtrace) with a rounded shape. They are impressed on the top surface of a dark grey sandstone fallen block at 200m to the west of Lighthouse beach (Fig.4). In order to infer the actual size, a 50% of reduction was calculated from the measurements of the subtraces. In some parts of the trackway the couples of hand and feet may be distinguished. They are assigned to an ungulate of median to small size.

Dimensions – Trackway: total length: 3.20m; maximum width: 0.40m; stride: 1.40m (based on the reduction of the subtrace); step angle: 152°. Subtrace – average diameter: 0.22m; average height: 0.04m; inferred depth: 0.02m Footprint:

average diameter: 0.11m.

Discussion – The high step angle and the reduced diameters of the footprints allow assigning this trackway to litoptern ungulates (Proterotheridae family). They were ungulates of very long limbs, and the lineal path trail observed in the trackway is proper of a long-limb ungulate locomotion. Proterotherids were very cursorial mammals thus considered like ecological akin or morphologically convergent with the Equidae of the northern hemisphere (SCOTT, 1937).

The morphology is similar to *Caballichnus impersonalis* (ANGULO & CASAMIQUELA, 1982), however that nomination is not adopted here since the authors used that name for the description of Equidae footprints (Order Perissodactyla). According to the land mammal records, horses did not inhabited South America during Pliocene times. They migrated from North America and reached Argentina by Late Pleistocene.

Occurrence 2 – La Loberia beach. A proterotherid trackway of six footprints and two isolated footprints impressed on the abrasion platform at the intertidal zone of the beach.

Description – Footprints assigned to ungulate mammals of median size. Each footprint (hand or feet undistinguishable) is subcircular in shape and some of them show a narrow rim around it. Toes and pad details are not observed.

Dimensions – Trackway: total length: 1.65m; maximum width: 0.60m; stride: 0.55m; step angle: 130°. Ichnite: average length: 0.135m; average width: 0.11m; depth: 0.04m.

Carnivora Marsupials

cf. *Thylacosmilidae*

Occurrence – About 200m to the West of Lighthouse beach. The footprints are impressed in a red brown clay fallen block.

Description – Trackway formed by six footprints impressed by a digitigrad mammal of median to big size. Each footprint shows five toes clearly marked, particularly the 3rd, the 4th, and the 5th. The scar of short claws is also inferred into the basin of the footprint because the feet sank in the mud at every step. A wide and thick sole pad is inferred resulting in a footprint wider than longer (Fig.5). Thick pads are inferred from the comparison with *Thylacinus*.

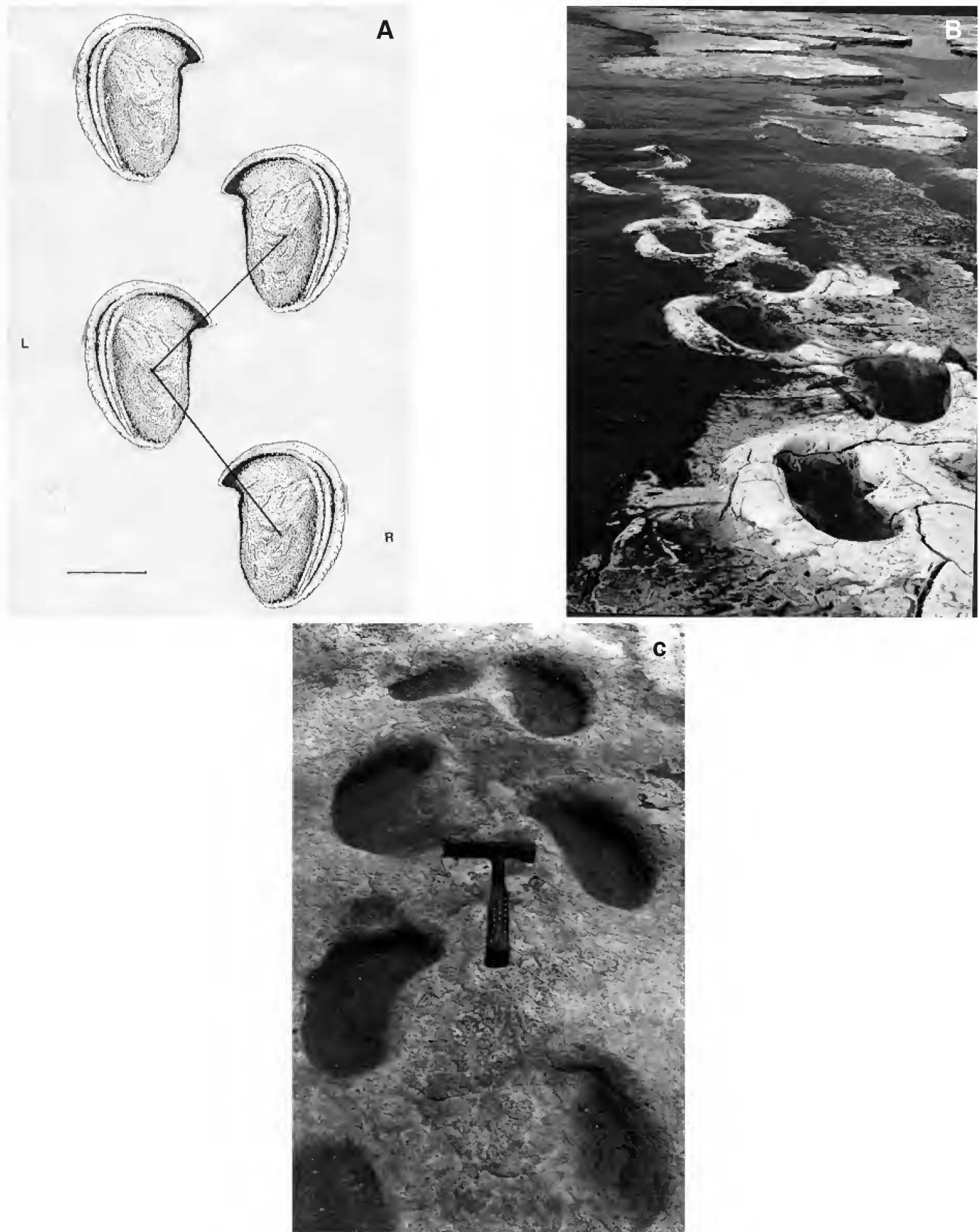


Fig.3- Ground sloths footprints. (A) Pattern of a bipedal locomotion. L: left; R: right. Lines indicate step angle. Scale bar = 0.25m; (B) cf. *Megatherichnum oportoi*. Trackway of bipedal locomotion; observed *in situ* at 7km to the west of Lighthouse beach. Hammer = 0.30m; (C) cf *Mylodontidichnum* isp. trackway of bipedal locomotion, observed *in situ* at 1.5km to the west of Lighthouse beach.



Fig.4- Ungulate *indet.* Circular subtraces on the top of a fallen block; 200m to the west of Lighthouse beach.

Dimensions – Trackway: total length: 1.61m; maximum width: 0.55m; central width: 0.65m; step angle: $163^{\circ}45'$; stride: 1.095m. Footprint: width: 0.096m; length: 0.075m; average depth: 0.0525m.

Plaster cast – P.ICHN.U.N.S. 101

Discussion – Hands and feet are undistinguishable; however, features like footprints wider than longer, toes with acute claws, depth of footprints, and digitigrade stance allow to assign the trackway to a conspicuous carnivorous mammal. Considering

the fact that there were not true Carnivora at early Pliocene, and that some marsupials exerted the carnassial role, it is possible to assign those footprints to a carnivorous marsupial, similar in size at least with *Thylacosmilus* sp.

Caviomorph Rodents

cf. *Porcellusignum* isp. Angulo & Casamiquela, 1982

Occurrence – Lighthouse beach.



Fig.5- Cf. *Thylacosmilidae* Ichnite *in situ* and plaster cast P.ICHN.U.N.S.101

Description – Imprints in trampling, showing three and four digits footprints, on platforms and isolated blocks. They are printed in concave epirelief and show a deep rounded palm/plant impression (Fig.6).

Dimensions – Footprints: four toes: width: 0.10m; length: 0.95m; depth: 0.04m; average divarication angle: 55° (Fig.7). Three toes: width: 0.09m; length: 0.85m; depth: 0.025m; average divarication angle: 58°.

Discussion – The footprints are assigned to hand (four toes) and feet (three toes) of a hydrochoerid rodent, which is consistent with the finding of teeth and jaws of *Protohydrochoerus*, an unusual discovery made in a fallen block (ANGULO & CASAMIQUELA, 1982; PASCUAL & BONDESIO, 1985). The footprints are assigned to *Porcellusignum* isp., according to the diagnosis proposed by ANGULO & CASAMIQUELA (1982) although the provided illustration is not eloquent.

AVES

Order: *Gruiformes* (*Ralliformes*)
cf. *Cariamidae*

Occurrence – Lighthouse beach, 200m to the west of Lighthouse beach. A bird trackway on the top surface of a fallen block together with trackways of an ungulate (Figs.8-9).

Description – Tridactyl footprints impressed by

birds of big size. The footprints are preserved in a negative epirelief. They are rather asymmetric being the 3rd toe of bigger size as regards the lateral toes and of wider base; 2nd and 4th lateral fingers diverging from the middle toe in a different angle. Lateral toes are half the size of the middle one. The impression of the convergence point of the three fingers (node) is deeply marked indicating the step of a heavy bird.

Dimensions – Trackway: stride: 1.61m; step angle: 157°; average height of the subtrace: 0.07m. Subtrace: length: 0.38m; width: 0.353m. Footprints: length: 0.25m; width: 0.176m; divarication angle 82° (2nd toe); 72° (4th toe).

Plaster cast – P.ICHN.U.N.S. 102

Assigned material – An isolated imprint from the platforms at La Lobería; only central and one lateral toe is preserved.

Discussion – The trackway is assigned to a phorusrhacid bird due to the big size and stride. It is remarkable that the 2nd or inner toe has a higher divergence angle than the 4th toe. No impression of the 1st toe is observed, probably because it was very short and did not reach the substrate.

Other bird footprints

Occurrence 1 – Two trackways located at 400m to the West of Lighthouse beach, printed on a fallen block of dark gray sandstone.

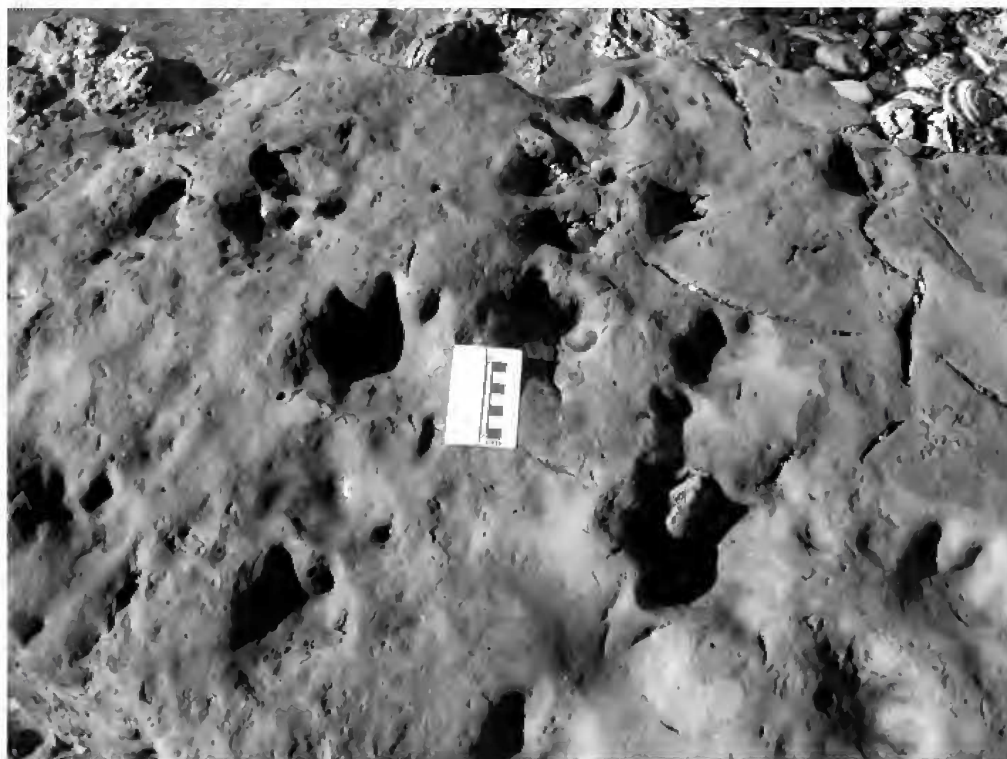


Fig.6- Cf. *Porcellusignum* isp. Block with footprints. Scale in cm



Fig.7- Cf. *Porcellusignum* isp. Isolated hand imprint.

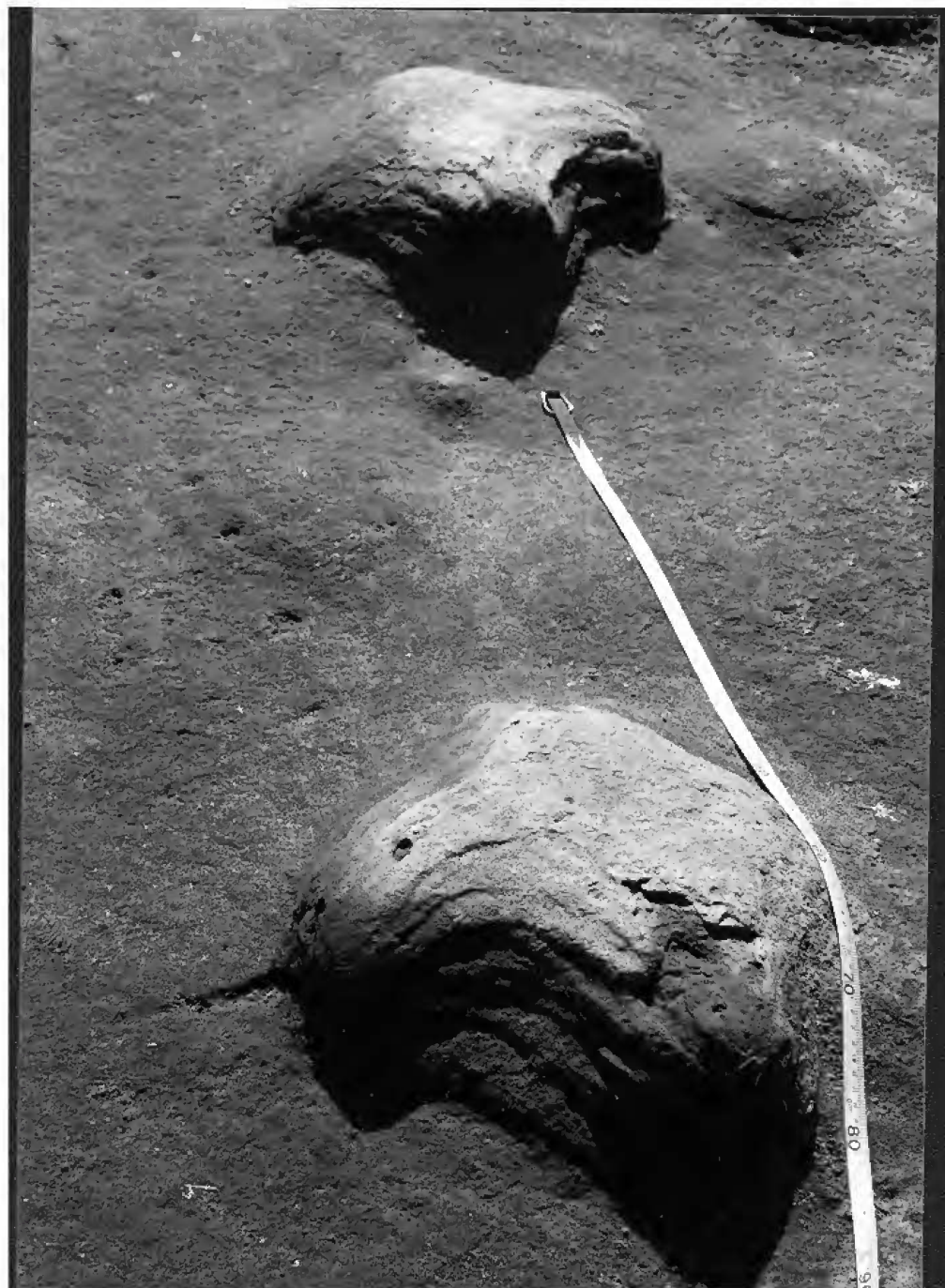


Fig.8- Cf. Cariamidae. Two subtraces. The extended metric ribbon is 0.90m long.

Description – Undetermined tridactyl footprints with straight toes, 3rd toe slightly longer than 2nd and 4th. The node is separated from the toes and is indicated by a shallow depression.

Dimensions – Trackway: length: 0.43m; Footprint: length: 0.063m; width: 0.063m; 3rd toe: 0.049m; average divarication angle of 2nd and 4th toes: 40°.

Occurrence 2 – Lighthouse beach, platforms at

the low tide line coast, formed by brown and yellow clays.

Description – A trackway of tridactyl imprints with an interdigital web, reminding the living flamingoes footprints (Fig. 10).

Dimensions – Trackway: length: 1.90m; Average pace length: 0.35m. Footprint: length: 0.08m; width: 0.12m.



Fig.9- Cf Cariamididae and ungulate subtraces.

AGE AND PALAEOENVIRONMENTAL FEATURES

The age of the outcrops are estimated between 7 and 4 My (Late Miocene/Early Pliocene), considering the fossil bones obtained from the continental bed cliffs. Some of the material were studied by CASAMIQUELA (1974), PASCUAL & BONDESIO (1985) and ARAMAYO (1987), and agree with the estimated age. Fossil bones of that age are also found in Buenos Aires Province and in other parts of Argentina, but only one finding of a few footprints were registered at La Rioja Province (BONAPARTE, 1965).

ZAVALA & FREIJE (2001) stated that the ichnites were printed on the borders of shallow pools found between dunes, where animals joined looking for food and freshwater. Ground sloths and ungulates are herbivorous mammals while

carnivorous marsupials and the big birds had carnivore or scavenger habits. They represent also a faunistic autochthonous association before the entrance of North America immigrants, the "true carnivorous mammals", which will drive to extinction the mentioned marsupials and phorusrhacid birds.

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Fig.10- Flamingo footprints. Hammer = 0.30m.

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